BUFFALO'S WATER SUPPLY, WITH SPECIAL REFERENCE TO THE FILTRATION PROBLEM[1]

By Henry F. Wagner

The present water works system of Buffalo has been developed from plans made in 1905 by the engineers of the Board of Public Works of the city, subsequently approved, with a few minor suggestions, by an engineering commission consisting of Gen. George S. Field, Col. Thomas W. Symons and Dr. Rudolph Hering. At that time the supply was drawn through an intake in the Niagara river to what was originally known as the Front Avenue pumping station, a plant which was seriously overloaded. The intake crib was about 1000 feet from the shore line, at a point where the water was 16 feet deep. Water taken from this intake was considered at that time to be approaching a condition where filtration would be necessary; it should be recalled that in 1905 the usefulness of chlorination as a method of treating water supplies was unknown. It seemed best to abandon the proposed enlargement of the old intake, which would be a very costly undertaking, and to construct a new intake tunnel to what is known as the Emerald channel at the foot of Lake Erie, and to build a new pumping station. The relative location of these works is shown in figure 1. Measurements of the currents in this part of the lake showed that the polluted water moves along each shore and the water coming from the unpolluted lake moves toward the head of the Niagara River in the Emerald channel. As a supply of fair quality was then obtainable through the old intake, it was determined to retain it in service and to reconstruct the Front Avenue station. This was done without interrupting the service, a piece of work which aroused much praise from those who saw it in progress. The old station is now known as the Massachusetts Avenue station and is connected by a shore tunnel with the new intake, so that it can pump water from the Emerald channel.

The Niagara River inlet up to 1914 was the only source of supply.

[1] Read before the Buffalo Convention June 10, 1919.

It was first built in 1870, enlarged in 1895 and reconstructed in 1906. The current here is from 8 to 10 miles per hour and it was thought that a pure water would be obtained. The structure itself was quite a notable one for that period. Its foundation is laid upon the bed rock of the river and extends upstream for about 25 feet in a triangular-shaped mass of stone and cement, to break the force of ice floes which strike here with considerable force. This intake was intended to supply the reconstructed pumping station at Massachusetts Avenue, but during the last few years of its use it proved wholly inadequate for the rapidily growing demands upon it. In

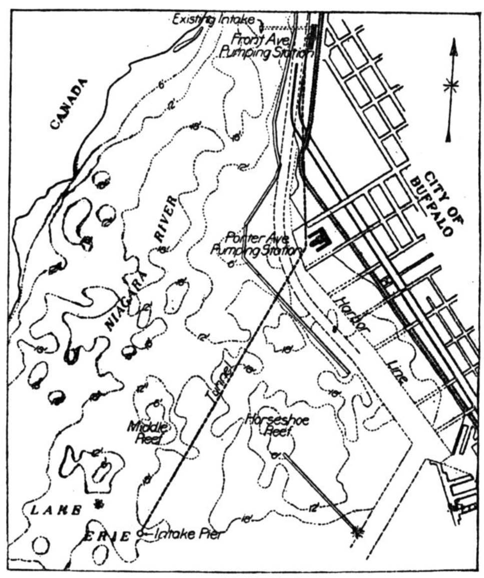

FIG. 1. BUFFALO INTAKES AND PUMPING STATIONS

the winter and spring, when ice was running in the river, it often became plugged with slush and anchor ice so that gangs of 200 to 300 men were required to work with shovels, scoops and steam lines in order to maintain the water level in the suction well. This supply also often became heavily contaminated by the harbor waters. Since the new Emerald channel inlet was completed, the old intake has been abandoned.

The Emerald channel intake, started in 1905 and completed in 1914, is a circular structure with an outside diameter of 110 feet.

The enclosing wall is of concrete 20 feet thick, leaving an interior chamber 70 feet in diameter. From the bottom of the lake and extending 2 feet above the mean water line, concentric steel shells $\frac{3}{8}$ inch thick incase the concrete wall inside and out. This wall extends 15 feet above the lake level. On the top, and set back 5 feet from the edge leaving a balcony clear around, is a brick wall 8 feet high. An ornamental iron railing encircles the balcony. The whole interior is roofed over half way with concrete covered with tile and the rest with heavy glass, all supported by steel trusses. The water is admitted into the interior chamber by twelve 6 by 6-foot ports, which are opened and closed by steam-operated gates. It has been found, however, that by keeping them open and thus lessening the force of the current flowing into the interior, there is less danger of anchor and slush ice plugging the gates. By this practice there is scarcely any perceptible current and the water is at lake level. In the center there is a shaft 12 feet in diameter which extends 60 feet below the surface and connects with and carries the water to the tunnel leading to the pumping stations. This is a 12-foot arched tunnel driven through limestone rock and has an 18-inch concrete lining. This tunnel is intercepted on shore by a second shaft, from which part of the water flows to the pumps at Porter Avenue by open canals and the rest is carried by a 9-foot tunnel to the Massachusetts Avenue station. There are installed on the pier, two 100 horse power boilers for furnishing heat and running a 10-kilowatt generator unit, which provides current for lighting the building including the fixed signal light which the government requires to be maintained as an aid to navigation.

The Massachusetts Avenue station is 640 feet in length and 102 feet in width. It houses six 30,000,000 gallon vertical triple-expansion pumps and two electric pumps of 25,000,000 gallons each. The electric pumps have been in disuse for several years and it is not expected that they will be put in operation again. The steam pumps are operated with 150 pounds of saturated steam which is produced by 16 horizontal tubular boilers of 300 horse power each and four water tube boilers of 600 horse power each. At the present writing but one pump at this station is in operation. The others, however, can be thrown into service at short notice should they be required.

The bulk of the water is supplied by the new station at Porter Avenue which was put into operation in 1914. This plant is one

of the largest of its kind under one roof and was constructed and equipped at a cost of about $2,500,000. The engine room is 95 by 364 feet and foundations are laid for eight pumps. Up to the present time five have been erected and are in use. The boiler room has space for sixteen boilers; eight are installed at present. They are the sectional water tube type of 750 horse power. High-pressure steam is utilized at this station at about 250 pounds and 100° of superheat. The total pumping capacity of the two stations is about 380,000,000 gallons and by the addition of three more pumps it is possible to furnish over 400,000,000 gallons of water.

The distribution is through two systems, the high and low. The initial pressure on the high-service ranges from 80 to 90 pounds and on the low-service 42 to 50 pounds. The high-pressure system in general takes care of the newest sections of the city, while the low supplies the older sections. In all, water is distributed through over 600 miles of pipe which range in size from $1\frac{1}{2}$ to 60 inches.

There is located in the northeastern section of the city a steel water tower 40 feet in diameter and 85 feet in height, figure 2. It stands on an elevation of 106.31 feet above the lake level and when filled to a depth of 75 feet holds 704,970 gallons. In the eastern sections of the city there is the Prospect reservoir, which covers 20 acres and when filled to a depth of 30 feet holds 116,313,827 gallons. At this stage the water surface is 113 feet above the pumping station. The tower is supplied by the high-service and the reservoir by the low, and by keeping the water in them at certain levels, a constant and uniform pressure is obtained throughout the city. In other words, the speed of the pumps and number in use at any time are dependent upon the height of the water in these reserve sources of supply. This information is telephoned to the pumping stations every half hour and action taken thereon accordingly.

As to the purity of the water supply, the author believes he is quite safe in saying that without any treatment at all it is as good as any available to cities having Lake Erie as their source of supply. The greatest contamination occurs during the summer months and a large part of it is due to freight and passenger vessels which generally use the north channel entrance to Buffalo harbor, which course takes them within less than 1000 feet of the inlet crib and on the upper side. Upon the opening of the summer resorts a short distance above, on the Canadian shores, several excursion boats ply back and forth from Buffalo hourly. These boats carry thou-

FIG. 2. THE KENSINGTON WATER TOWER

sands of people daily and with no restriction on the disposal of their sewage. This constitutes a great menace, as excreta from this source may easily pass into the water supply in a fresh and virulent state. The shore drainage adding to the pollution, while considerable, is not necessarily excessive, as there are no cities of any size above Buffalo whose sewage might find its way into the water supply. There are several streams flowing into the lake within easy radius of Buffalo but they are small and the tendency is for their water to follow inshore, as the extensive use of floats has proven. In the winter, after navigation closes and especially after the ice has formed, the water is of a most excellent quality. The bacteria count obtained on 37° agar is then very low. There is one aspect, however, which has to be given weight and that is with reference to the condition arising as a result of the hundreds of fishermen who go out on the ice to fish. The excreta which these people leave upon the ice is a constant menace to the water supply, more so at thaw periods and acutely so when, upon the coming of spring, the ice breaks up and all is carried in the direction of the crib. It can be seen, therefore, how most of the contamination occurs at uncertain periods. This condition makes it necessary for chlorine to be added to the water in sufficient quantity to take care of the high wave at all times, even though the dose may be in excess of that actually essential during three-fourths of the time.

The chlorination apparatus is located at the intake pier where the chlorine solution is injected into the mouth of the 12 foot arched tunnel. This, therefore, affords a run of over a mile in a leak-proof tunnel and ideal conditions for sterilization. The apparatus is of the float meter type. The float is about 3 inches long and has never caused any trouble from sticking, as has been the case where the small indicator was used. The chief trouble with this apparatus has been caused by the clogging of the pressure reducers, which requires taking them apart every once in a while and cleaning them. Generally it is necessary to replace the old diaphragms with new ones when this is done.

The amount of chlorine used ranges from 0.16 to 0.28 part per million. These figures are equivalent to about 1 pound and 2½ pounds per million gallons.

The author does not believe in any set and fixed standard for a safe water. In other words, the same standard is not applicable to any two waters, and when such is aimed at there is certain to be a

variation one from the other in actual practice. A set standard will be hard to abide by, because of the great difference in the kind and character of the pollution. While the standard may be too severe in some cases it may not be severe enough in others and therefore misleading. A standard is no sooner proposed for certain conditions than it is at once grasped and applied to a great variety of conditions. The Buffalo standard is that the bacteria count made on 20° agar is a gauge of the efficiency of the sterilization plant and means nothing as to whether the water is safe or not. The real knowledge is obtained from the test for organisms of the B. coli group. The author prefers to use lactose peptone bile as a medium. His aim is to eliminate gas formers to the extent that negative tests are obtained on four out of five 5 cc. samples of the treated water.

It is evident that Buffalo has an excellent water system. Physically the condition of the water is open to severe criticism from 10 to 15 per cent of the time, which brings up the subject of filtration. A glance at a map will show that Lake Erie lies to the west or southwest from Buffalo. It is from this direction that the winds come which prevail principally during the fall when the highest turbidity occurs. Compared to some water, this is not at all bad, as 250 parts in a million is about the maximum. It consists principally of very finely divided clay, the percentage of organic matter being very small. Generally the sediment is offensive for from three to six days at a time. The sediment is quite heavy and settles rapidly as soon as the disturbing element is removed; the second day after a blow the water has improved 50 per cent. In all, the water is noticeably turbid from thirty to sixty days of the year.

In planning for a filtration plant in Buffalo, consideration must be given to the following points. First, do the prevailing conditions of the water set forth warrant such an expenditure? Second, the water consumption must be reduced to a reasonable figure and waste to a minimum before such a project is feasible. Lastly and perhaps the most difficult problem is the suitable location for a filter plant. When the water works were originally laid out it seems the idea that Buffalo might some day have such a plant was not thought of or at least no provision was made for its possible location. As to the proposition that the water be pumped to an elevation outside of the city and returned by gravity, the city is handicapped by the flat nature of the country around it. To

secure an elevation anywhere near sufficient for the purpose it would be necessary to go at least 15 miles into the country. The enormous expense that would be incurred securing the right-of-way and in constructing a dual pipe line of the size which would be sufficient for the purpose would place too heavy a burden upon the resources of the city of Buffalo.

A solution of this problem will probably be found to the south of the Porter Avenue pumping station where there is a large tract of water-front land which is at present used for a dumping grounds. Part of this land is covered by the harbor waters but can be easily reclaimed by a retaining wall and subsequent filling in. This would furnish a location all that could be desired for a rapid sand filtration plant. The water could be diverted to the filters by short extensions to the existing canals and raised to the required height by low-duty pumps. After passing through the filters the water would be permitted to return to the original suction wells by gravity and be distributed through the present system.